

Applications of Smart Wireless Sensor Networks

CS 603
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Introduction

- Smart Wireless Sensor Network
 - Large number of sensors
 - Wireless communication
 - Intelligence
- Network Applications and Research challenges

Features

- Large scale(10,000 or more)
- Low power
- Network self-organization
- Collaborative signal processing
- Query Ability

Goals

- Value of some parameter at given location
- Detect occurrence of events of interest
- Classify a Detected object
- Track an object

Habitat Monitoring System

Uses

- Long-term data collection at scales
- Immediate physical environment
- Integration of local processing and storage
- Ability to communicate allows nodes to perform complex functions

Habitat Monitoring System

Problems faced

- Environment with high fidelity is expensive (Redwood canopies in forests, climate and occupancy patterns of seabird and animal tracking)
- Traditional data loggers are expensive and large in size. Sensors must be inconspicuous.
- Eg: 15 min visit to seabird colony result into 20% mortality among eggs and chicks

Solution by WSN

- WSN can be deployed where it is unsafe or unwise for attempt field studies
- Real-time data access without repeated visits to sensitive habitats
- Economical as compared for installing data loggers

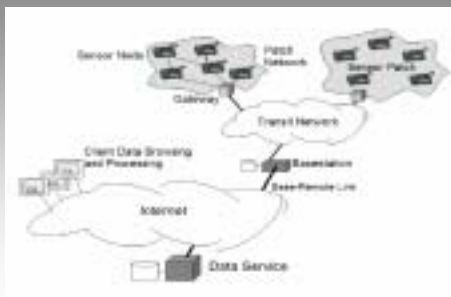
Great Duck Island

- Maine Island
- Monitors the microclimates in and around nesting burrows used by the Leach's storm Petrel

By

- Intel Research Lab. Berkeley
- College at Atlantic, Ban Harbor
- University of California, Berkeley

System Architecture



Implementation

- Sensor Network Node-Mica motes
- Sensor Board-Mica Weather Board
 - Temperature, pressure, humidity, photoresistor and thermopile sensors
- Sensor Deployment
 - July 2002
 - Acrylic enclosure used
- DBMS- Postgres SQL
 - Data from sensors
 - Health status
 - Metadata(sensor location)

- User Interface
 - Matlab provide powerful interface for relational database
 - Java applet provide ubiquitous interface to the habitat data
 - Gizmo design for local users is developed and experimented on a Compaq iPaq PDA running Linux

Acceleration Sensing Glove (ASG)

By
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Acceleration Sensing Glove

Main Goal: To demonstrate that accelerometers can be used as sensors to detect and translate finger and hand motions into computer interpreted signals.



Acceleration Sensing Glove(ASG)

Hardware



- Wrist Controller
- 6 accelerometer
 - 5 at finger tips
 - 1 at back of hand

Acceleration Sensing Glove(ASG)

Software

Data should be

- Calibrated: Orienting the glove in particular position
- Normalized: w.r.t gravity
- Low pass filtered: Signal are averaged to reduce white noise

Coordinate transformation

$$(x,y) \rightarrow (R_{acc}, \theta)$$

Static Data Analysis



- In static situation only force acting is gravity G
- Orientation of accelerometer relative to gravity is θ
- The angle the acceleration plane is offset from horizontal plane is ϕ
- Accelerometer at the back of the hand acts as Tilt motion detector
- Accelerometer at thumb, index finger and middle finger operates as mouse click

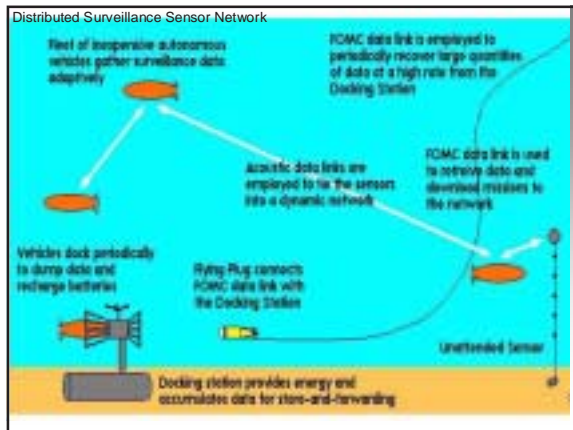
Future Potential Applications

- Wireless wearable mouse pointing device
- Wireless wearable keyboard
- Hand motion
- Gesture recognition tools
- Virtual musical instruments
- Computer sporting games
- Work training in Simulated environment

Distributed Surveillance Sensor Network (DSSN)

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Distributed Surveillance Sensor Network

Applications

- It can act as sonar capable of detecting and localizing anomalies within the sea water
- It is possible to detect mines and submarines in the water

Smart Home

Characteristic

- Close proximity and highly interactive
- Individuality
- Spatial density of the object in household applications are very high

Challenges

- Ubiquitous computing system
- Hardware-related system
- Application-related issues

Applications

- Address object as individual(eg. Where is my passport)
- Address objects in term of features(eg. Is there empty bottle)
- Organizing things in temporal set(set of clothes, products, traveling)

RIFD(Radio frequency Identifiacion) DVD Store

- Search DVD by entering name and light blinks
- Mode of payment will be electronic
- RFID tag tied to a sensor can communicate the interior temperature and humidity
- Track of inventory (warehouses, out of stock)

Applications

- Automatically pay tolls
- Implanted ID chips for pets and livestock
- Cash card in Singapore and Hong Kong for Subway

Educational Applications

Introduction

- “Person to physical object” interaction
- Sensor sense events and condition about people and object in environment and act upon sense info.
- Respond to user queries and commands
- Physical embedded reactive systems

Educational Applications

Challenges

- Instead of computing and communication, embedded computing and interaction with physical objects
- Architecture, algorithms and formalism
- Issue of data management

Smart Kindergarten

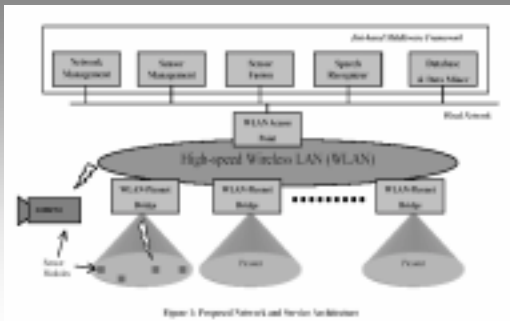
Deployed at

- UCLAs Corinne A. Seeds university elementary school
- Classroom project 2000 at Georgia Tech
 - Recordings of the lectures

Challenges

- Not the traditional synchronous lecture but unstructured asynchronous playing and problem-solving oriented environment in the classrooms for young kids.
- The user base of the young kid is much more challenging than the college students
- Richer traditional audio, video and pen strokes.
- Key challenges are in
 - Creating a new networked sensing approaches
 - Networking protocols optimized for large scale and high density
 - Processing and analysis of data generated by all these sensors to extract useful information and patterns after appropriate aggregation, filtering and reduction.

System Architecture



1. Sensing Infrastructure

- Main goal is to capture sensor data such as identity, absolute location, relative location, audio/speech, image/video, orientation, motion, acceleration, touch/pressure, light and temperature at appropriate spatial granularity, and feeding the extracted information after appropriate processing to a behind-the scene data management server.
- There are three broad categories of instruments used: cameras for video/image (high bit rate), microphones (and speakers) for audio/speech (medium bit rate) and other sensors (which are mostly low bit rate).

2. Wireless Networking and Sensor Middleware Services

- 100 to 1000 objects
- Data rate of >10000 bits per sec. for streaming videos
- 2-tiered wireless sensor network arch.
- Energy efficient medium access and channel allocation algorithms for an operations environment where there are 10s of devices per square meter

3. Sensor Data Management Service

Challenges

- Data models, query languages and storage structures to support capture, query, mining and browsing repositories of audio, video and a variety of sensor data
- Mining of profiles

Solution

- Audio and Video are stored in repository
- Data is stored as XML doc and can be indexed, queried and browsed
- All the records are needed offline for analysis

Military Applications

Tools for the Battlefield of the future

- Robots that can crawl caves, sniff out people and explosives, and radio their finding to commanders miles away
- Bombs (sensors and communication devices)
- Oak Ridge National Lab, Tenn.
- Albuquerque lab

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